DEVELOPMENT OF HIGH-PERFORMANCE, REDUCED-TEMPERATURE SOFC POWER SYSTEMS

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Extended Abstract

AlliedSignal has been developing high-performance, portable solid oxide fuel cell (SOFC) power systems operating on a variety of fuels (including logistic fuels such as JP and diesel). The two key components of the system are a reduced-temperature SOFC module for electric power generation and a partial oxidation reformer for hydrocarbon fuel processing. The SOFC module is based on cells having micrometer-thick electrolytes made by tape calendering and thin-foil metallic interconnects. The fuel processor employs the partial oxidation of hydrocarbons with air to produce hydrogen and carbon monoxide. The system has many attractive features for portable uses including light weight, low volume, and multifuel capability. This paper discusses the development status of this system with emphasis on the fuel processor, the SOFC module, and the system design.

Logistic Fuel Processor: A processor based on partial oxidation is being developed for converting logistic fuels to hydrogen and carbon monoxide. The partial oxidation process permits a compact design of the processor suitable for use in portable power systems. AlliedSignal has established the operating conditions for the processor to run on logistic fuels. Based on these conditions, a reactor has been designed and has been successfully operated on JP and diesel fuels containing up to 1,000 ppm sulfur. Stable performance with up to 90% CO yield and 80% H_2 yield has been obtained. Sulfur exits the processor as hydrogen sulfide with little sulfur dioxide detected.

SOFC Module: The design of SOFC modules or stacks for portable power systems is based on thin-electrolyte cells and thin-foil metallic interconnects. Two stack design configurations (cross flow and radial flow) have been evaluated for this application. To date, cross flow and radial flow stacks having various footprint areas and heights have been assembled and operated. Stack testing has consistently shown stable open-circuit voltages of about or more than 1 V per cell. High performance and high power densities (up to 0.6 W/cm² at 800°C with hydrogen) have been obtained and reproduced for multicell stacks. Preliminary thermal cycle tests have demonstrated stack thermal cyclability. A 30-cell stack of cross flow configuration (10 cm x 10 cm footprint) was recently tested. The stack produced about 1.1 kW at 21 V at 800°C on hydrogen, with a potential peak power of 1.4 kW. This is the first reduced-temperature kW-class SOFC stack operation reported in the literature.

Portable System Design: While the SOFC is the fundamental electrical power generating component, there are several other key components or subsystems required to support and control the operation of the fuel cell to meet the requirements of specific applications. AlliedSignal has performed extensive system design to integrate the SOFC into a complete system, including fuel and oxidant delivery, startup, fuel processing, thermal management, and various control and regulating devices. Modeling and analysis have been conducted to define all subsystems in terms of performance, weight, size, reliability, and costs. Several variations of system and subsystem configurations have been evaluated to determine the optimum combination of subsystems.

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